Searches for Non-SM Higgs Bosons at the Tevatron

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On behalf of the DØ & CDF Collaborations

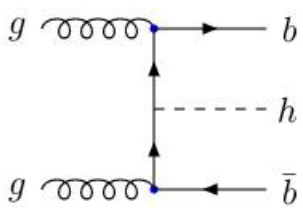
Moriond QCD March 16th, 2005

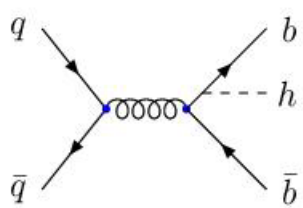
Outline

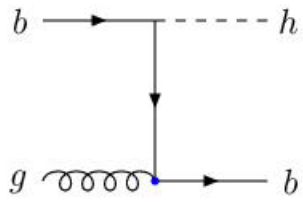
- SUSY Higgs Bosons
  - Search for h(→bb)bb (DØ)
  - Search for hX →ττX (CDF)
- Long-Lived Doubly Charged Higgs Bosons (CDF)

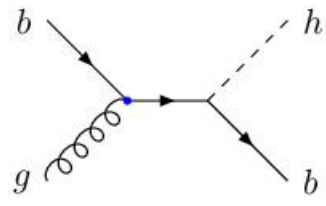
SUSY Higgs

- In two Higgs doublet model, such as MSSM
  - 5 physical Higgs bosons → h, H, A, H^+, H^- ($m_h < m_H$)
- $\tan\beta = v_u/v_d$: ratio of vacuum expectation value of 2 Higgs
  - Cross sections for bbh enhanced like $\tan^2\beta$
  - Tevatron is sensitive to large $\tan\beta$ and $m_A >$ ~90 GeV
- h is predicted to be light ($m_h <$ ~135 GeV)
  - LEP limit is $m_h >$ ~92 GeV @ 95 C.L.
- At high $\tan\beta$, A is almost degenerate with h/H
  - $\sigma(A) \sim \sigma(h/H)$, $\Gamma(A) \sim \Gamma(h/H)$
  - Br(A→bb) ~ Br(h/H→bb) ~ 90%
    - Another 10% is Br(A/h/H→ττ)
  - hbb(→bbbb) and hX→ττX are the best channels to search for h/H/A



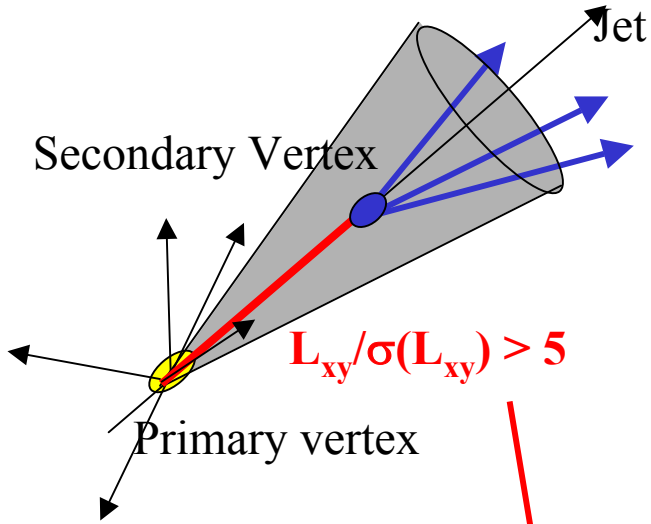


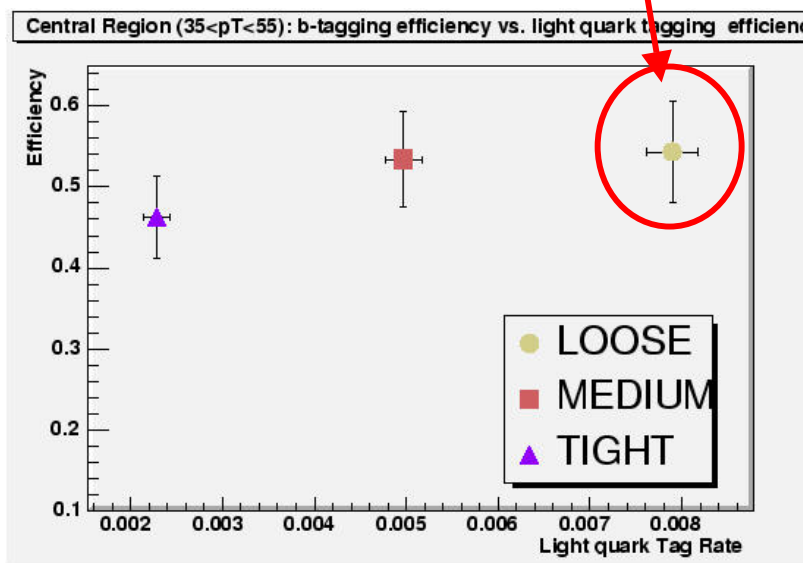




h(→bb)bb Search (DØ)

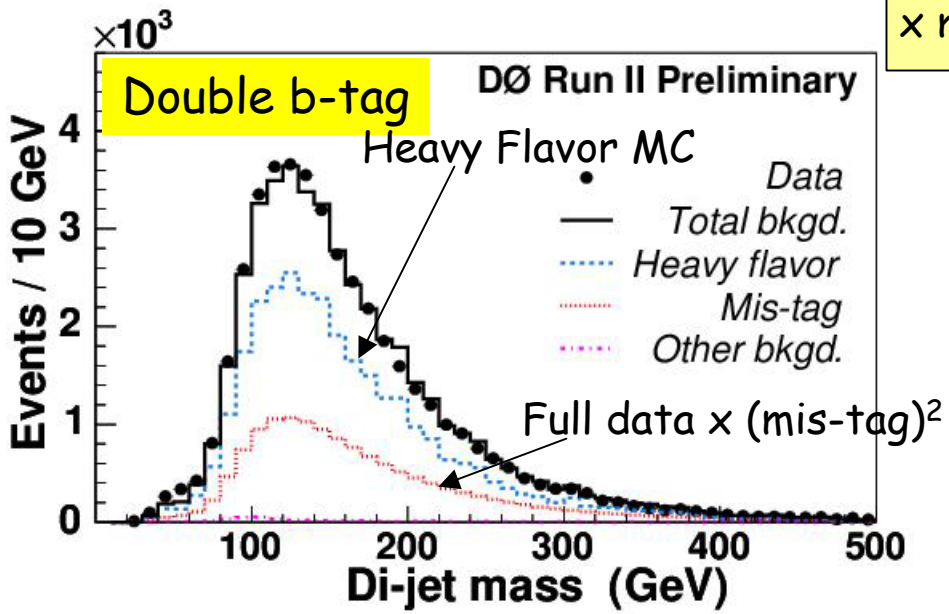
- L=260pb^{-1}
  - Trigger : at least 3 jets with E_T→15GeV
- Selection
  - Offline selection on leading jets optimized for each Higgs mass
  - Secondary Vertex b-Tagging
    - Double b-tag and Triple b-tag
- Backgrounds
  - QCD fake: jjjj … From Data
  - QCD heavy flavor:
    bbjj, ccjj, cccc, bbcc, bbbb
    … From Data
  - Other: Z(bb,cc), tt … From MC
- Simulations
  - SM Higgs … PYTHIA
    - σ and kinematics adjusted to NLO (P.R.L 94, 031902(2005) Dawson et.al)
  - Background
    - PYTHIA,ALPGEN,MADGRAPH



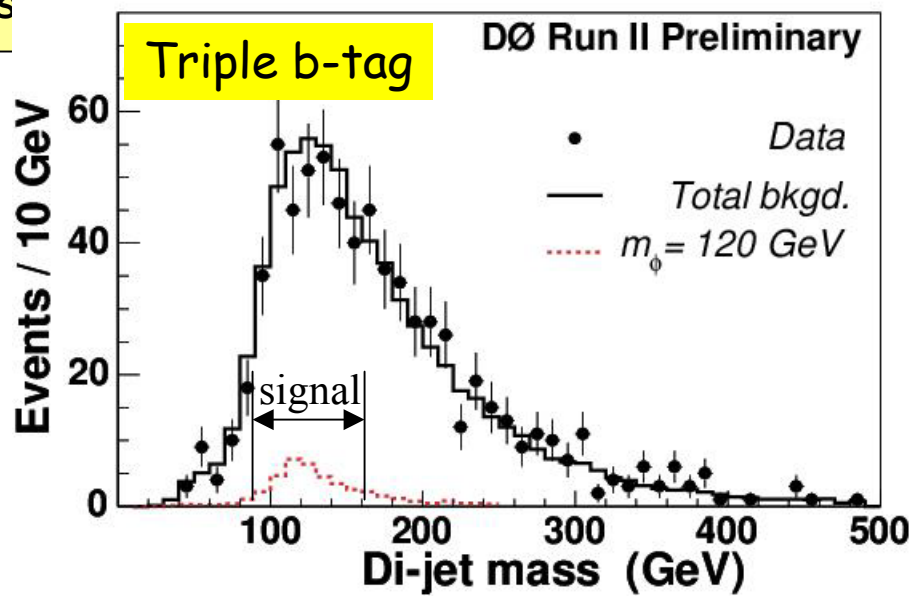


h(→bb)bb Search (DØ)

- "mis-tag" rate function from full samples (as a function of p_T and η)
  - ~2%
- (double b-tag data) x (mis-tag rate) = (triple b-tag backgrounds)
  - Shape of events with ≥ 3 b-jets similar to double b-tag distribution
  - Their cross sections are very small
- Fitting triple b-tag dijet mass distribution outside the signal region

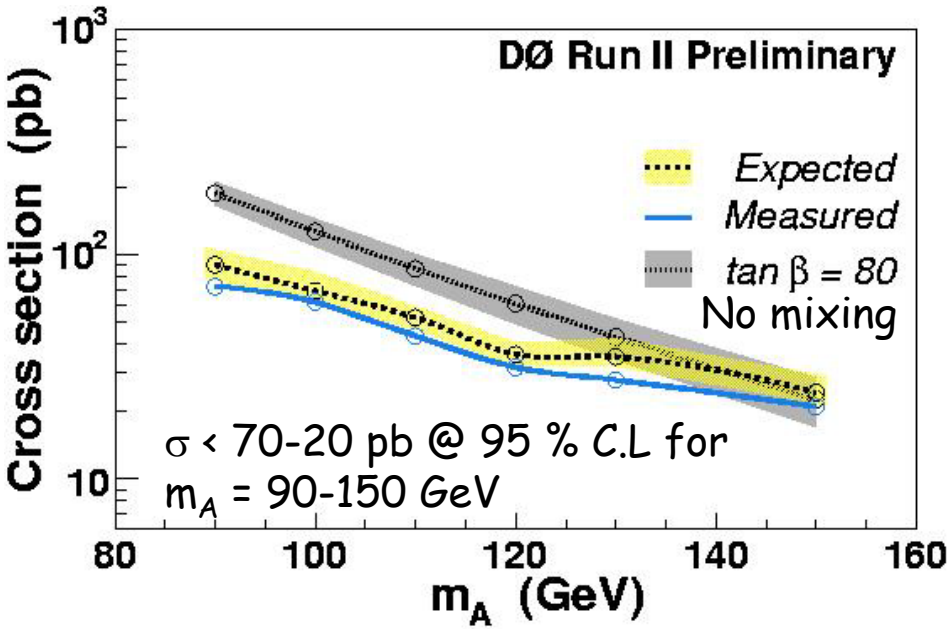


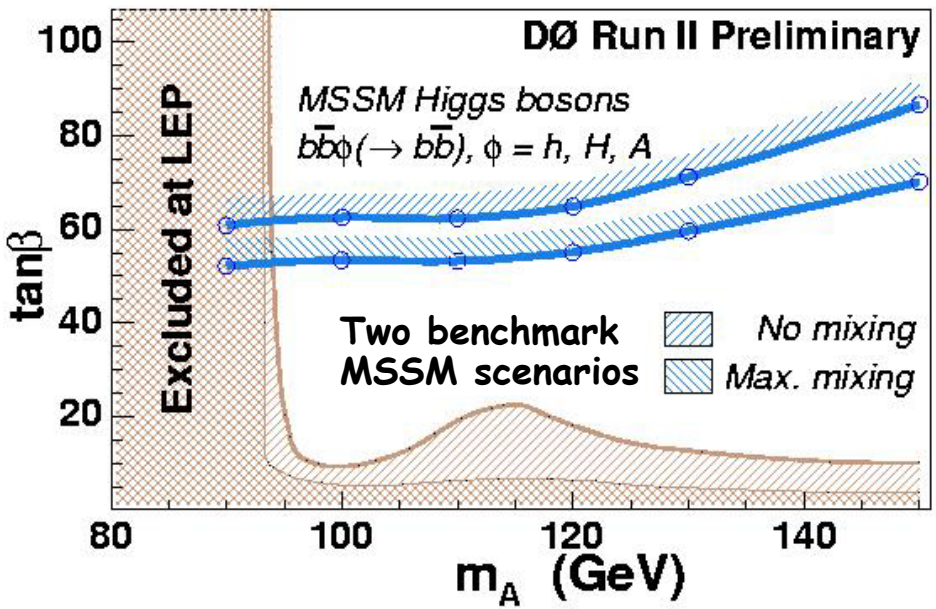
x mis



h(→bb)bb Search (DØ)

- No evidence and Set Limits on cross section & tanβ vs. m_A plane
  - Set limits on tan β vs. m_A in two of the "benchmark scenarios"
    - "No mixing" and "maximal mixing" in the stop sector
      max-mix : designed to maximize allowed parameter space
  - Exclude significant portion of tanβ down to 50, depending on m_A and MSSM scenario



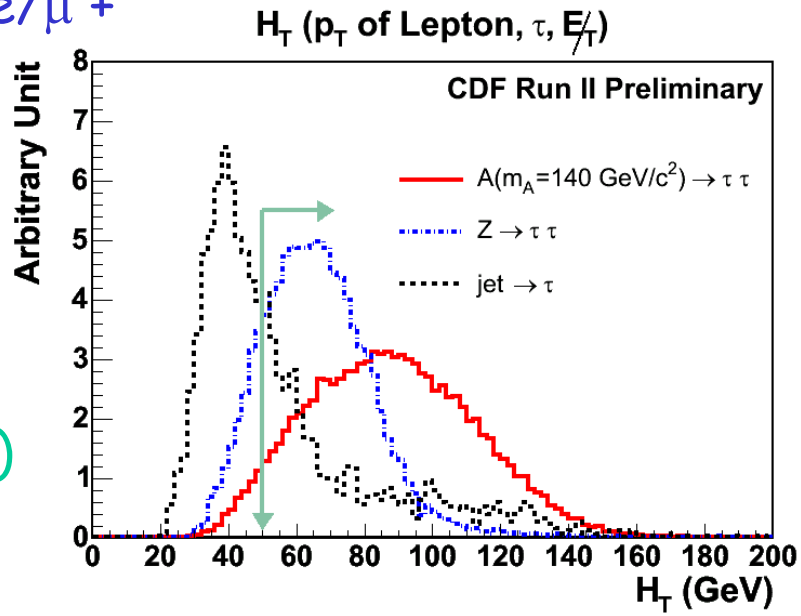


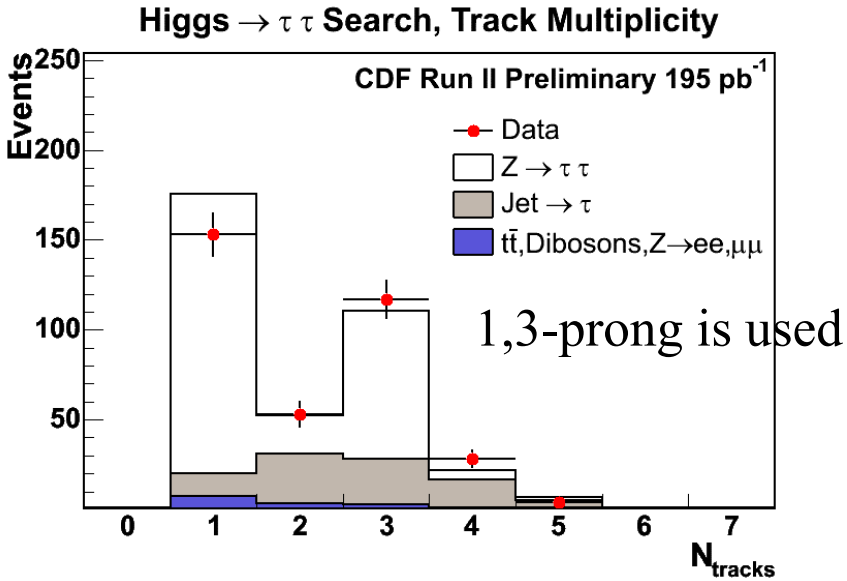
For m_A = 120 GeV:

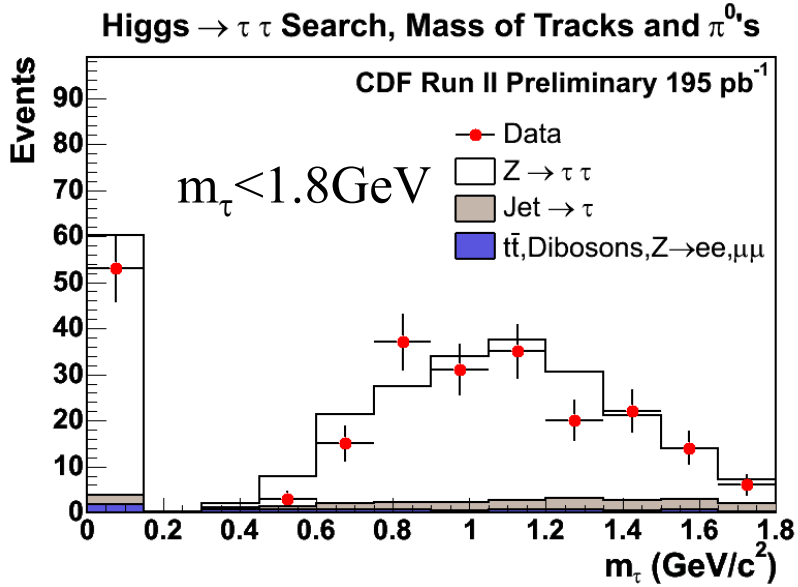
σ < 31 pb @ 95% C.L. , tanβ < 55 @ 95% C.L. (Max Mixing)

hX→ττX (CDF)

- 200pb^{-1} sample collected by τ triggers (e/μ + isolated track)
  - $\tau_{e/\mu} \rightarrow e/\mu + \nu\nu$, $\tau_h \rightarrow$ hadrons + ν
- Selection
  - lepton pT, Z mass window cut
  - Isolation on the τ_h
  - Event Topology using $\not{E}_T$, $p_T(\tau_l)$, $p_T(\tau_h)$
    - $H_T = |p_T(\tau_l)| + |p_T(\tau_h)| + \not{E}_T > 50$ GeV
    - $\not{E}_T$, $p_T(\tau_l)$, $p_T(\tau_h)$ correlations







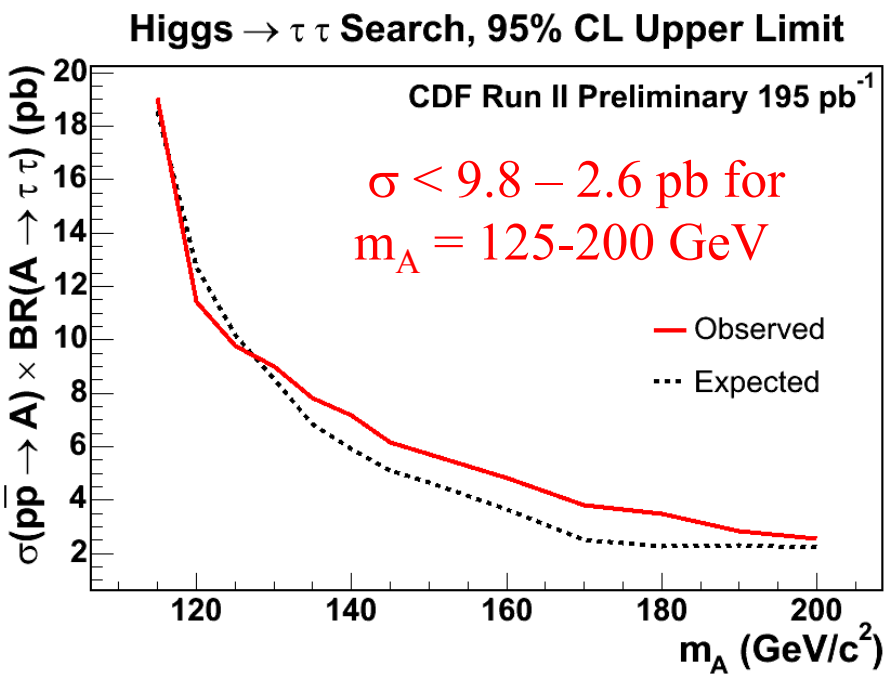
h→ττ (CDF)

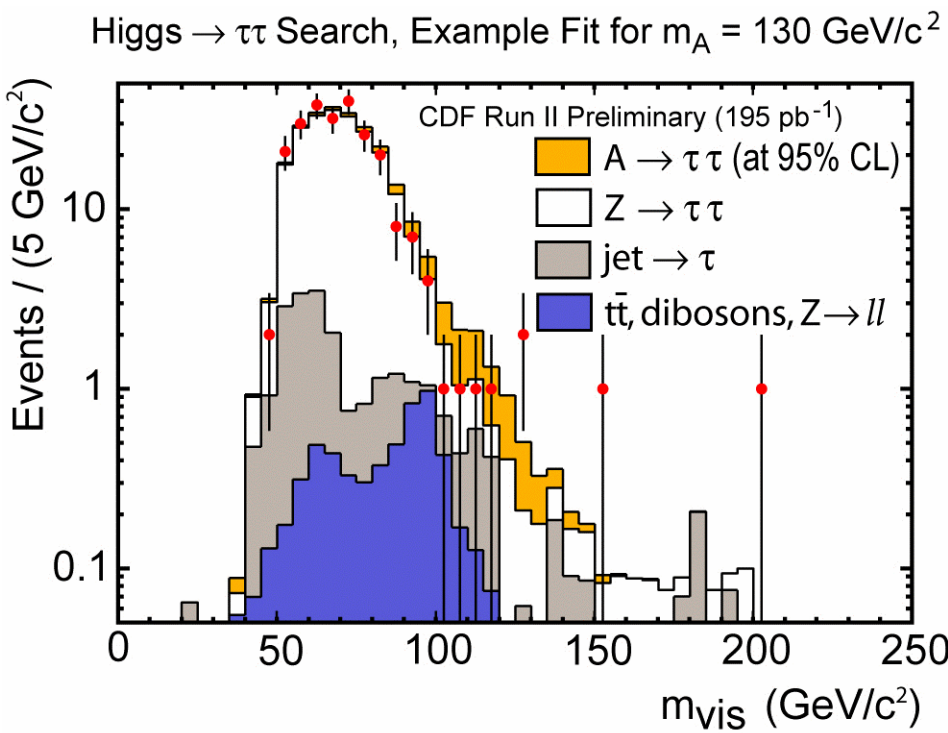
- Limits on σxBr extracted from likelihood fits of m(l,τ_h,$\not\!\!E_T$)
  - Signal Acceptance
    - PYTHIA + TAUOLA
    - 115GeV < M_A < 200 GeV
    - Effi. ~ 0.8% ($\tau_e\tau_h$), ~ 0.6% ($\tau_\mu\tau_h$)

MSSM Higgs → ττ Search, final events

	$\tau_h\tau_e$	$\tau_h\tau_\mu$	Combined
$Z \to \tau\tau$	132.3 ± 17.1	104.1 ± 13.3	236.4 ± 29.5
$Z \to ll$	1.8 ± 0.2	4.9 ± 0.4	6.7 ± 0.6
$t\bar{t}, VV$	0.7 ± 0.1	0.8 ± 0.1	1.5 ± 0.1
$jet \to \tau$	12.0 ± 3.6	7.0 ± 2.1	19.0 ± 5.7
Total predicted	146.8 ± 17.5	116.8 ± 13.5	263.6 ± 30.1
Data	133	103	236

CDF Run II Preliminary





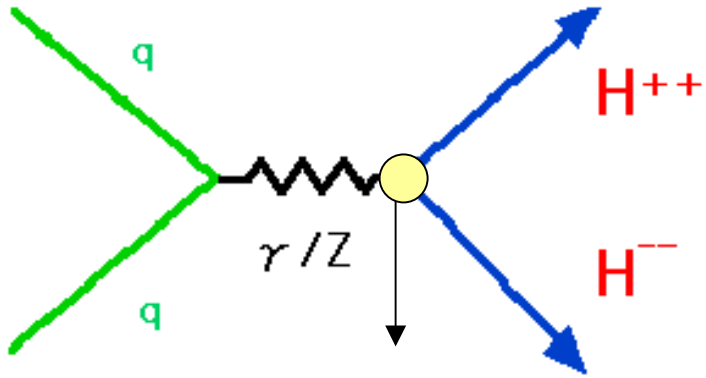
Doubly-Charged Higgs Boson

- Appeared in several extensions to the SM and can be relatively light
  - Left-Right Symmetric Model
  - Higgs Triplet
  - Little Higgs Model
- If short lived:
  - Invariant mass of like sign dilepton

  DØ (113pb^{-1}) m(H_L) > 118 GeV 95% C.L.

  CDF (240pb^{-1}) m(H_L) > 136 GeV 95% C.L.
- If long lived ($c\tau$ > 3m)
  - Can be measured by two high ionization tracks

  DELPHI : m($H^{\pm\pm}$) > 99.6 GeV @95% C.L.



Coupling depends on L/R Handedness

Long-lived H^{++}/H^{--} Search (CDF)

- L~290pb^{-1} collected by muon trigger
- pT(track) > 20 GeV
- dE/dx from drift chamber
  - dE/dx depends on (charge)^2

  →Signal modeled by quadrupling the dE/dx of cosmic muons (~4x15ns)
- No Evidence found
- Limits on cross section

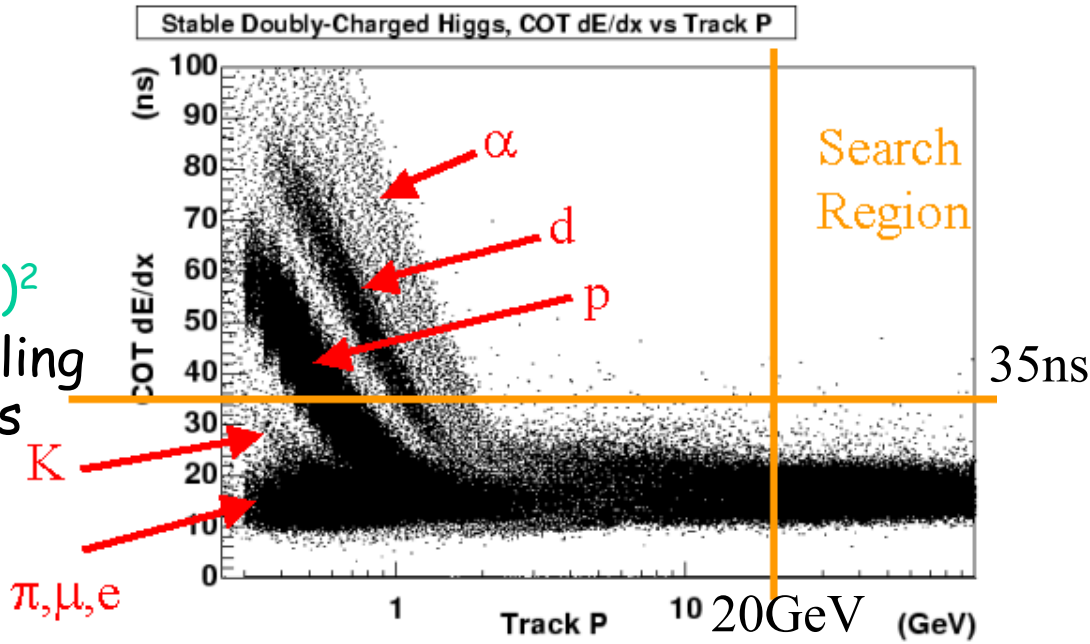
  σ < 39.7– 32.6 fb @ 95%C.L.

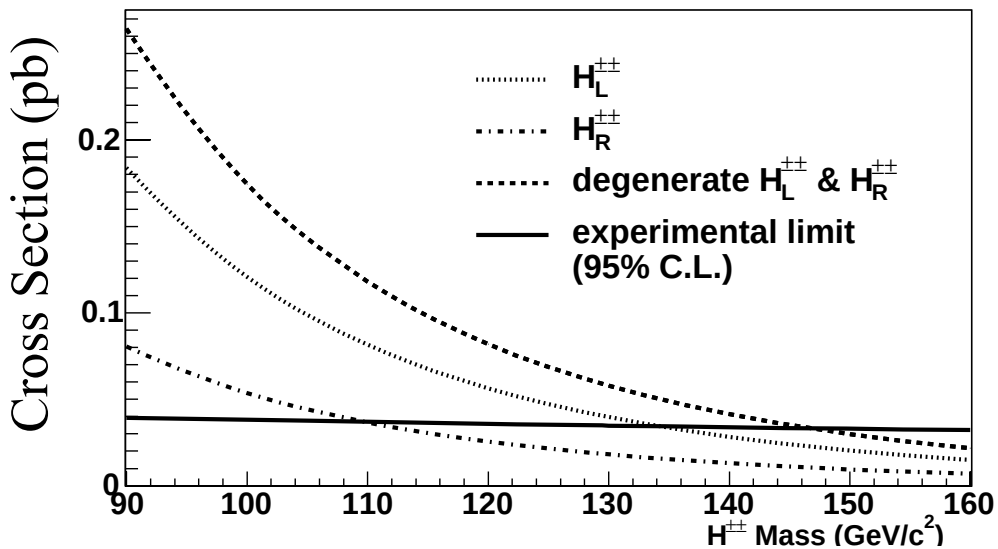
  for m($H^{\pm\pm}$)=90-160GeV
- Mass Limits

  m($H_L^{\pm\pm}$) > 133 GeV @ 95 C.L.

  m($H_R^{\pm\pm}$) > 109 GeV @ 95 C.L.

  m($H^{\pm\pm}$) > 146 GeV @ 95 C.L.





Summary

- CDF and DØ searched for several non-SM Higgs bosons based on data of L=200-300pb^{-1}
  - h(h→bb)bb from DØ
  - hX→ττX from CDF
  - Long-lived double charged Higgs from CDF
- No evidence of excess found
- Start excluding significant portion of parameter space
- New channels and improved results will come
  - Twice more luminosity available